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USE OF BOULDER POCKET HABITAT BY RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) IN FALL RIVER, IDAHO

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Abstract.—Abundance of rainbow trout (*Oncorhynchus mykiss*) in relation to characteristics of pockets created by boulders was studied in Fall River, southeastern Idaho. To determine depth and surface area of pockets most selected by rainbow trout, fish were counted by snorkeling, and pocket physical dimensions were measured. An electivity index defined habitat selection in the following terms: the most suitable habitat was ≥0.7 m maximum depth, ≥0.5 m minimum depth, and ≥3 m^2 surface area. Some study reaches of Fall River had more suitable pockets available for trout than were being utilized.

Key words: rainbow trout, Oncorhynchus mykiss, *habitat use, Idaho, stream rehabilitation.*

Boulders create a major source of trout habitat in many higher-gradient western rivers. They create pools or pockets with increased depth and provide surface turbulence that may be the only cover available to trout. Water depth and boulder cover were important in determining density of trout in a Colorado stream (Stewart 1970). Boulder placement is a commonly used technique in stream rehabilitation (Rosgen and Fittante 1986) and may provide effective, durable trout habitat (Lere 1982).

This study evaluated age-1 and older wild rainbow trout (*Oncorhynchus mykiss*) use of boulder pocket habitat in Fall River, Idaho. Objectives were to determine the proportion of trout using boulder pocket habitat, and to assess the extent to which fish selected pockets of specific surface area and depth.

Methods

The Fall River originates in the southwest portion of Yellowstone National Park. It flows east into Targhee National Forest, Idaho, and then through agricultural lands to join Henrys Fork of the Snake River approximately 10 km south of Ashton in Fremont County. The study area, at an elevation of about 1740 m, extends 7 km, half of which is within the Targhee National Forest and half immediately below. The stream channel has been shaped by coarse-grained glacial outwash through which it flows. Basalt and ash flow tuff bedrock define the channel form. Sinuosity is low, approaching 1.0, and there are no meander pools. Overall gradient in the study reach is 0.64%.

Within-channel habitat was homogeneous and consisted predominantly of run habitat, as defined by Helm (1985). Little woody debris had been retained in the channel. At the 14–16 m^3/sec low flows of late summer 1991, the stream margin had pulled away from any vertical banks formed by high flows, leaving no bank habitat to provide cover for larger trout. The study reach contained Paiute sculpin (*Cottus beldingi*), longnose dace (*Rhinichthys cataractae*), and a few Utah suckers (*Catostomus ardens*) and mountain whitefish (*Prosopium williamsoni*) in addition to the wild rainbow and occasional cutthroat (*Oncorhynchus clarki*) trout.

In August of 1990 and 1991 snorkel surveys were conducted to estimate trout density throughout the study area. These indicated that density of trout larger than age-0 averaged 0.35 fish/100 m^2, or approximately 136 fish/km (Griffith unpublished data). Three sites, representing a range of boulder pocket densities, were selected for the present study. Sites were 160–170 m long and averaged 26–46 m wide. A boulder was defined as ≥0.4 m diameter, situated so that its top was at or above the water

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TABLE 1. Characteristics of boulder pockets used by 83 rainbow trout in three study sections of Fall River, Idaho, summer 1991.

Characteristic	Number of occupied pockets	Number of trout	Trout per pocket	
			Average	Range
Maximum depth (m)				
<0.46	0	0	—	—
0.46–0.55	2	3	1.5	1–2
0.56–0.65	7	16	1.7	1–5
0.66–0.75	15	30	2.0	1–5
0.76–0.85	8	19	2.4	1–5
0.86–0.95	2	3	1.5	1–2
0.96–1.05	2	8	4.0	
1.06–1.15	1	4	4.0	—
Minimum depth (m)				
<0.26	0	0	0	—
0.26–0.35	1	1	1.0	—
0.36–0.45	6	12	2.0	1–4
0.46–0.55	11	24	2.2	1–4
0.56–0.65	10	26	2.6	1–5
0.66–0.75	9	20	2.2	1–5
Surface area (m^2)				
<0.46	0	0	—	—
0.46– 0.75	2	2	1.0	—
0.76– 1.25	1	2	2.0	—
1.26– 1.75	3	4	1.3	1–3
1.76– 2.25	2	3	1.5	1–2
2.26– 2.75	3	7	2.3	2–3
2.76– 3.25	6	13	2.6	1–4
3.26– 3.75	5	11	2.2	1–5
3.76– 4.50	4	8	2.0	1–3
4.51– 5.50	2	5	2.5	1–4
5.51– 6.50	1	2	2.0	—
6.51– 8.50	2	4	2.0	—
8.51–11.00	1	3	3.0	—
11.01–13.50	1	2	2.0	—
13.51–16.00	1	4	4.0	—
16.01–20.50	1	3	3.0	—
20.51–26.00	1	4	4.0	—
26.01–30.00	1	5	5.0	

surface to create a pocket of lower velocity water immediately downstream. The low boulder density site (LBD) had 38 boulders that fit these criteria and averaged 0.5 boulders/100 m^2 of stream surface. The intermediate boulder density site (IBD) had 60 boulders (average 1.0 boulders/100 m^2), and the high boulder density (HBD) site contained 84 boulders (2.1 boulders/100 m^2).

During the last two weeks of August 1991, boulder locations in each site were mapped and trout focal point positions recorded by a snorkeler moving slowly upstream. Fish larger than about 15 cm were included, with most 15–25 cm and a few as large as 30 cm. No effort was made to differentiate fish by size categories. Underwater visibility was approximately 4 m, and water temperature ranged from 14° to 19° C from 1000 to 1500 MDT when observations were made.

After snorkeling, we recorded dimensions of all pockets in the section. We demarcated the lateral margins of a pocket by the abrupt change in water velocity that occurred there. Initially we used a velocity meter (Marsh-McBirney model 201) on a range of pockets in each site and then completed demarcation by eye. Water velocity, which ranged from 0.8 to 1.2 m/sec along the thalweg outside boulder pockets in all sites, was generally 0.3–0.5 m/sec within the pockets.

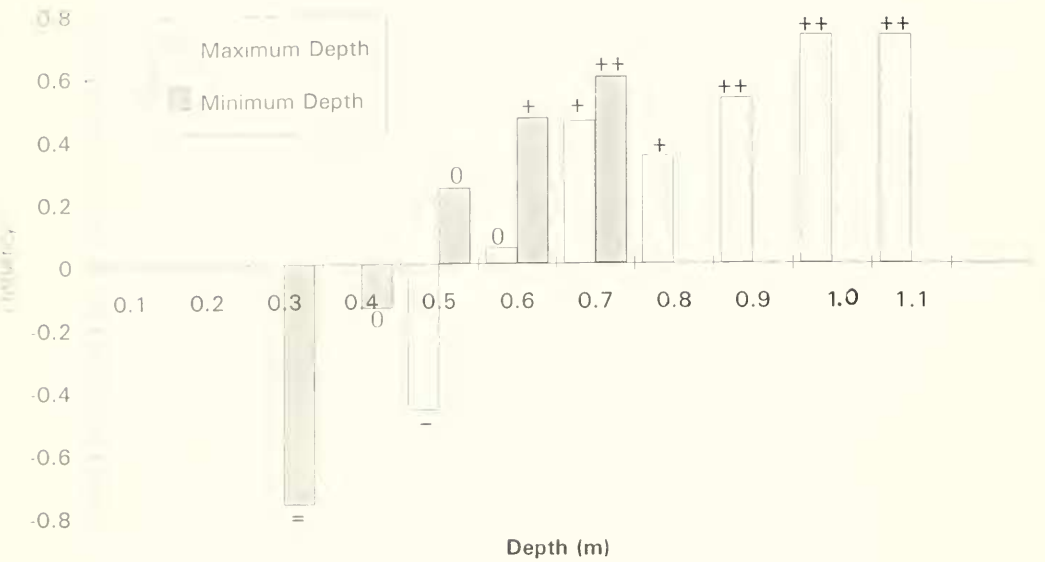

Fig. 1. Minimum depth (m) and maximum depth (m) of boulder pockets used by rainbow trout in Falls River, Idaho. Electivities are indicated: ++ (≥0.5, strong selection), + (>0.25 but <0.5, moderate selection), 0 (±0.25, no selection), – (>−0.5 but <−0.025, moderate avoidance), and = (≤−0.5, strong avoidance).

To evaluate the selection by trout of the pocket parameters, an electivity index (D) was calculated:

$$D = \frac{r - p}{(r + p) - 2pr}$$

where r is the proportion of the resource used by rainbow trout and p is the proportion available in the environment (Baltz and Moyle 1985). Following Baltz and Moyle (1985), we interpreted strong selection to be indicated by D ≥ 0.5, moderate selection >0.25 but <0.5, no selection 0 ± 0.25, moderate avoidance > −0.5 but < −0.25, and strong avoidance ≤ −0.5. Electivity values were calculated for maximum and minimum depth and surface area of the boulder pockets.

RESULTS

There was a wide range of maximum and minimum depths and surface area of boulder pockets available on Fall River. Maximum depth among the three study sites ranged from 0.3 to 1.1 m and averaged 0.7 m. Minimum depth ranged from 0.2 to 0.7 m, averaging 0.45 m. Pocket surface area ranged from 0.25 to 28 m² and averaged 2.4 m². The larger and intermediate-sized pockets were primarily found in the HBD reach, and smaller pockets were primarily found in the LBD and IBD reaches.

Pocket surface area was partially a function of boulder diameter, with pocket area = 1.881 + 4.5572 × boulder diameter (R^2 = .57, N = 182) for all sites combined. The correlation was higher at lower boulder density sites; but at the HBD site, area of an individual pocket was also affected by the presence of adjacent boulders.

All trout observed in the study sites were in boulder pockets. Eighty-three fish were found, with 0, 17, and 66 at sites LBD, IBD, and HBD, respectively. The total number of boulder pockets holding trout was 10 (17% of pockets present) at IBD and 27 (32% of pockets present) at HBD. A comparison of utilized pocket measurements showed no significant difference between the two sites (P < .05) and the data were pooled for analysis.

As water depth and surface area of a pocket increased, the number of fish present generally increased (Table 1). No trout used pockets in which minimum depth was less than 0.26 m and maximum depth was less than 0.36 m.

As surface area increased, the number of fish per pocket generally increased to a maximum of 5 (Table 1). Average number of fish per pocket was 1.4 in pockets with surface areas <2.25 m², 2.2 in surface areas of 2.26–4.50 m², 2.2 in

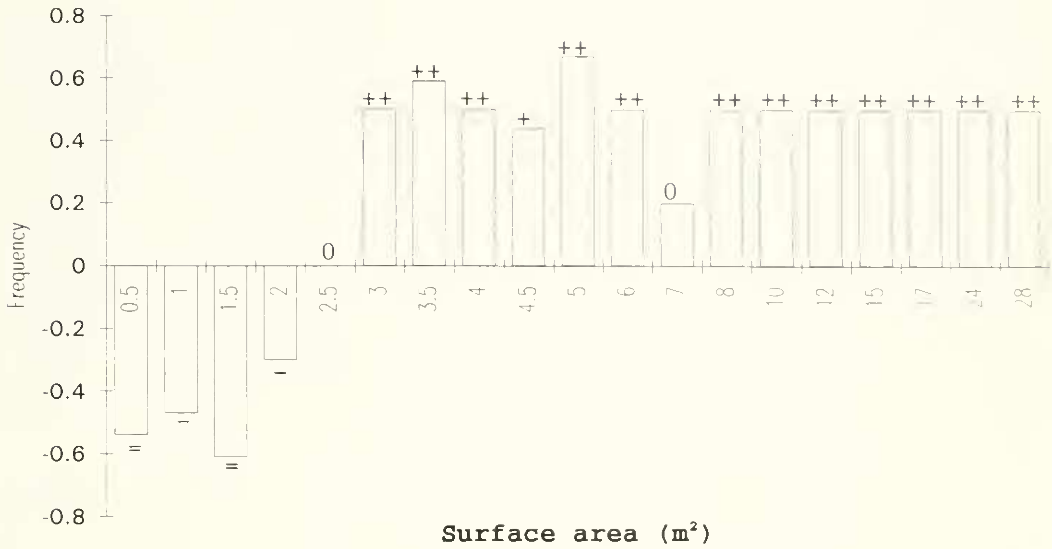

Fig. 2. Surface area (m²) of boulder pockets used by rainbow trout in Falls River, Idaho. Electivities are indicated: ++ (≥0.5, strong selection), + (>0.25 but <0.5, moderate selection), 0 (±0.25, no selection), – (>−0.5 but <−0.025, moderate avoidance), and = (≤−0.5, strong avoidance).

surface areas between 4.51 and 8.50 m², and 3.5 in surface areas >8.5 m².

The electivity index demonstrated that trout were selective in the microhabitat they occupied. Electivity values for maximum depth indicated moderate selection at depths equal to or greater than 0.7 m and strong selection at depths greater than 0.9 m (Fig. 1). Minimum pocket depth was not a sensitive index of trout density. At minimum depths of 0.6 m and deeper there was moderate selection and over 0.7 m, strong selection (Fig. 1). Pockets with surface areas equal to or exceeding 3 m² were moderately or strongly selected (Fig. 2).

Habitat for which rainbow trout showed a "strong" or "moderate" selection was viewed by us as the most suitable habitat for the study sites. Fifty of the 178 pockets in the three sites fell within those limits. Thirteen optimal pockets were located within the IBD reach and none within the LBD reach. Thirty-seven were located within the HBD reach, and more fish were found in that reach. A total of 23 of the 50 optimal pockets were not occupied by trout.

DISCUSSION

Maximum water depth in boulder pockets strongly influenced selection of habitat by rainbow trout in the Fall River. Baltz and Moyle (1985) evaluated rainbow trout habitat in a tributary of the Sacramento River, California, and found strong selection for depths greater than 0.6 m, similar to the threshold value for our study. The Habitat Suitability Index (HSI) for rainbow trout (Raleigh et al. 1984) indicates that depths greater than 0.46 m have a suitability index value of 1, the highest value possible. Not until Fall River pocket depths of ≥0.7 m were reached was there moderate to strong selection, and trout moderately avoided pockets at depths of 0.5 m; thus, the HSI did not accurately predict depth selection on Fall River. Minimum pocket depth appeared to be a less useful indicator of habitat selection for Fall River rainbow trout.

Pocket surface area was also a factor affecting trout density. Only four fish were found in pockets <1.5 m², and those >3 m² were selected. Lewis (1969) found that surface area and depth along with volume, current velocity, and cover accounted for 70–77% of the variation in numbers of trout in pools of Little Prickly Creek, Montana.

If surface area "requirements" reflect the size of territories defended by individual trout, in optimal habitat agonistic behavior by individual trout might serve to establish maximum density. Allen (1969) and Grant and Kramer (1990) reviewed the literature for fluvial salmonids; though data for rainbow trout were limited, strong similarities were found among the seven salmonid species they reviewed. For fish 15–20 cm long, average territory size in pools was approximately 1–5 m^2. In Fall River the estimated area occupied by individual trout, based on our observations of fish abundance per pocket, ranged from 0.5 to 6.0 m^2 and averaged 2.5 m^2. However, two-thirds of the fish were inhabiting areas < 2.5 m^2, suggesting that smaller territories might be required in boulder pockets than in the pools from which the data of Grant and Kramer (1990) were generated.

Lack of summer holding habitat in the LBD reach appeared to limit trout abundance, as the reach contained no quality pockets and no trout were present. Summer holding habitat did not appear to limit trout numbers in the HBD and IBD reaches because there were 23 pockets with optimal dimensions that were not utilized. Trout density in these reaches might have been depressed by low recruitment or factors such as winter mortality and food availability.

Although trout distribution is closely tied to physical habitat in Fall River, it is clear that simply adding boulders to rivers will not automatically increase trout populations. Pockets created by boulders must meet depth and surface area requirements before fish will inhabit them, as shown on Fall River. Other studies have found that water depth alone is not the major limiting factor for trout populations (Kennedy and Strange 1982); water velocity and available cover also influence trout density (Lewis 1969). These environmental requirements as well as other limiting factors must be understood before boulders are effectively used for habitat improvement.

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